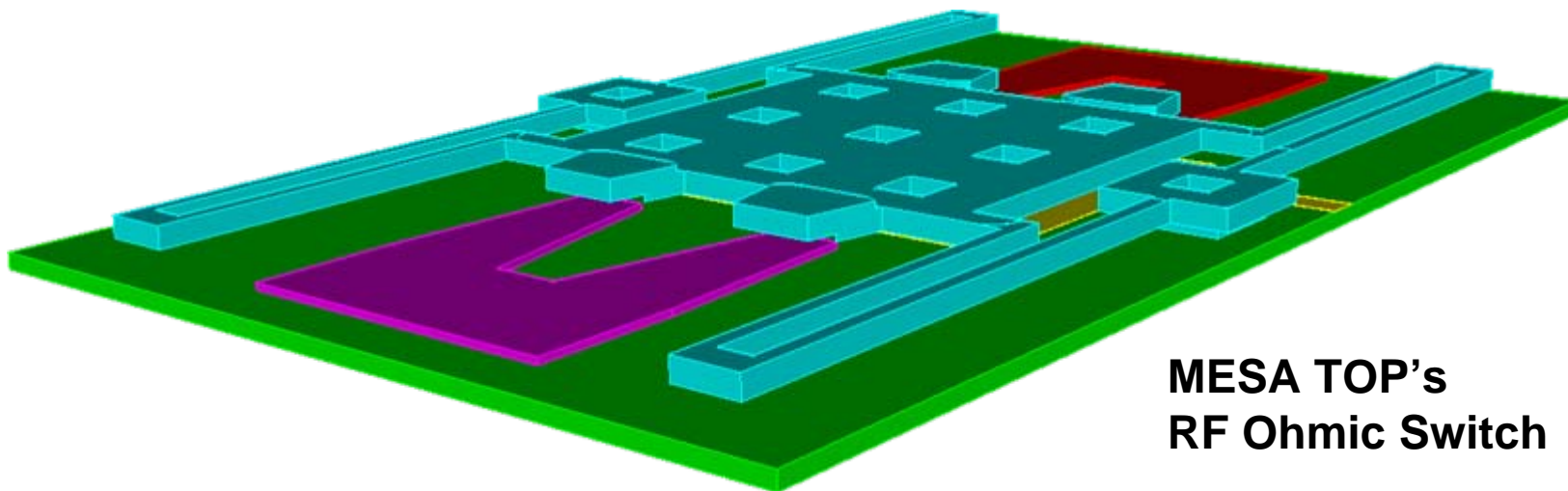# 9211 Review

# High Performance Computational Science for MESA

**MESA TOP's
RF Ohmic Switch**

June 2005

Steve Thomas

# Overview

**Objectives**

**Accomplishments**

**MESA Culture and Challenges for 9200**

**RF Ohmic Switch  Design Optimization**

**CIS R & D Opportunities**

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# Objectives

**<u>Goal:</u>**

**9200 contributions recognized as indispensable to MESA success and vision.**

**<u>Objectives:</u>**

**Establish a 9200 presence within MESA TOP**

**Demonstrate the value of optimization**

**Serve as point of contact ("ambassador") for broadening 9200's involvement.**

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# Accomplishments

**Membership in  two MESA TOP product teams**
        **- RF Ohmic Switch**
        **-Micro SAR Phased Array Antenna**

**MESA TOP Co-Location**

**0.5 FTE MESA program funding for FY06**

**Ohmic Switch team will undertake optimization-based re-design, fabrication, test cycle in <u>FY05</u>**

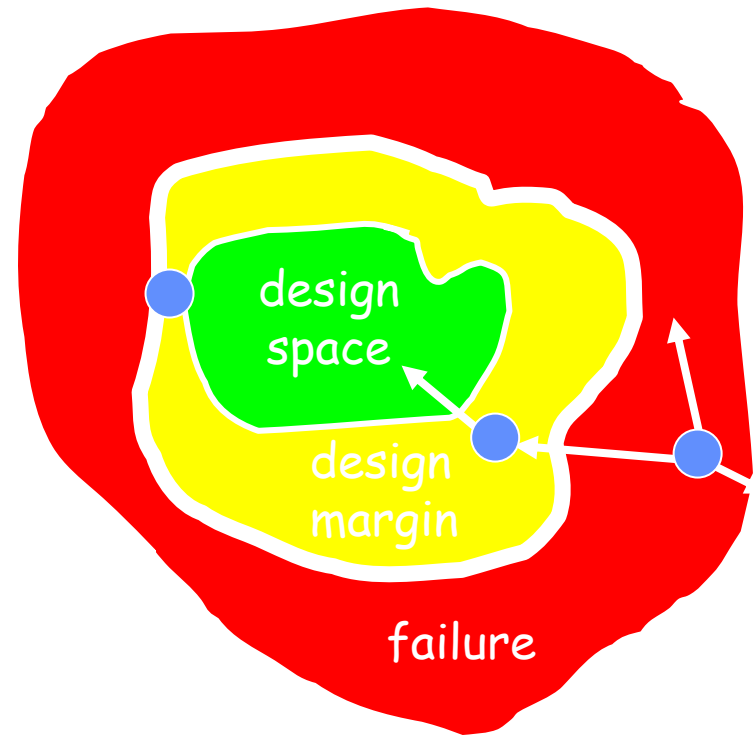# Nature of the MESA Opportunity for 9200

- **Strengths**
  - **Excitement of creating new products with new technology**
  - ***New design playing field* creates new, valuable opportunities for modeling, simulation and optimization**
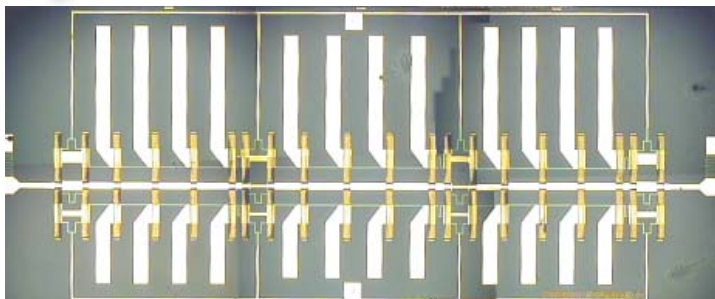
- **Challenges**
  - **MESA TOP recognizes, funds microtech *product team* contributions exclusively**
  - **Product teams are *multidisciplinary***
  - **Contribution is measured by acceleration of *product readiness* - "Research publication is counter-productive."**

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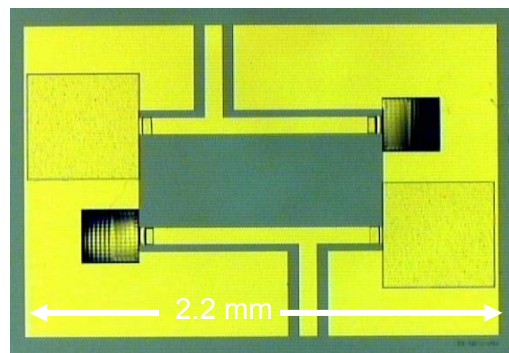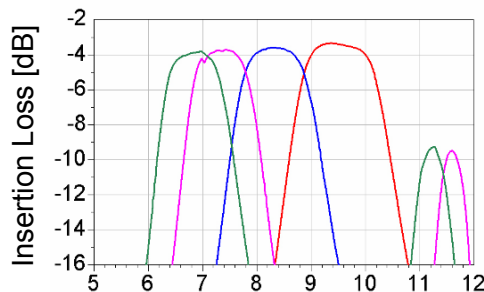
# Unique Microsystems Design Considerations

• Design constraints, opportunities quite different from macro world
  
  –e.g. *use* RF coupling rather than *avoid* it.

•Many designs can be built on a single wafer
  
  - Build all variations, test to see what works best!

• Long Fab-times:  multi-level processes: several months
  
  - e.g., SUMMiT V

• Quantitative visual inspection of product requires significant effort
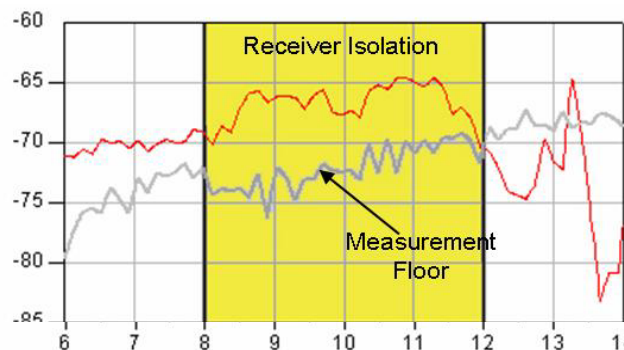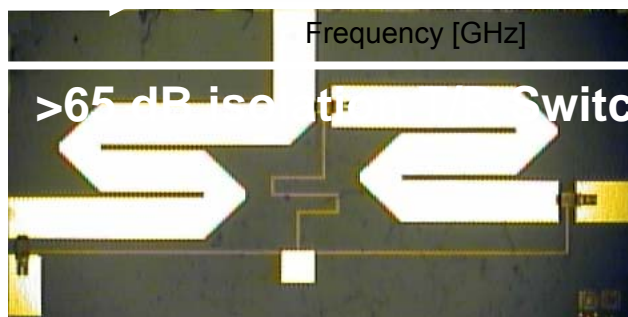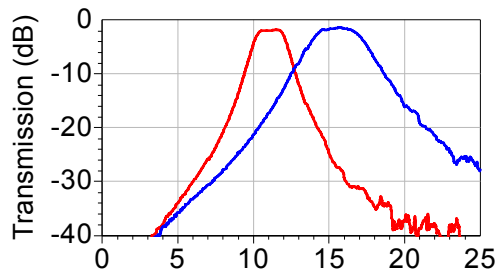
design space

design margin

failure

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# Reconfigurable Circuits and Devices



8.9 mm



Insertion Loss [dB] vs Frequency [GHz]

>65 dB isolation Switc
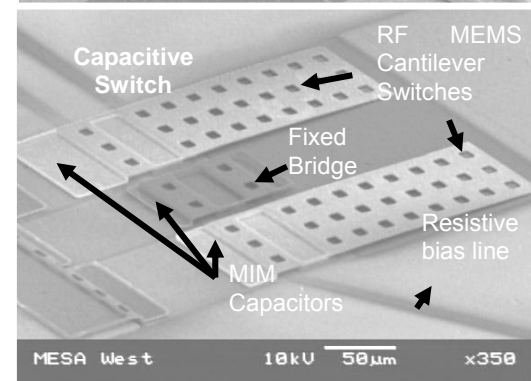


2.2 mm

Transmission (dB)



Receiver Isolation

Measurement Floor

- **RF MEMS Switches**
  - **Enabling technology**
  - **<0.1 dB loss**
  - **Near-zero Power**
  - **High Linearity**



Metal Contacting Switch

Anchor

CPW Signal Line

Contact

Ground Resistor



Capacitive Switch

RF MEMS Cantilever Switches

Fixed Bridge

Resistive bias line

MIM Capacitors

MESA West    10kV    50µm    x350

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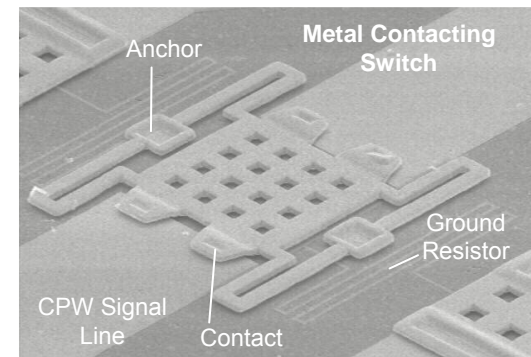
# Sandia Ohmic RF MEMS Switch



Spring
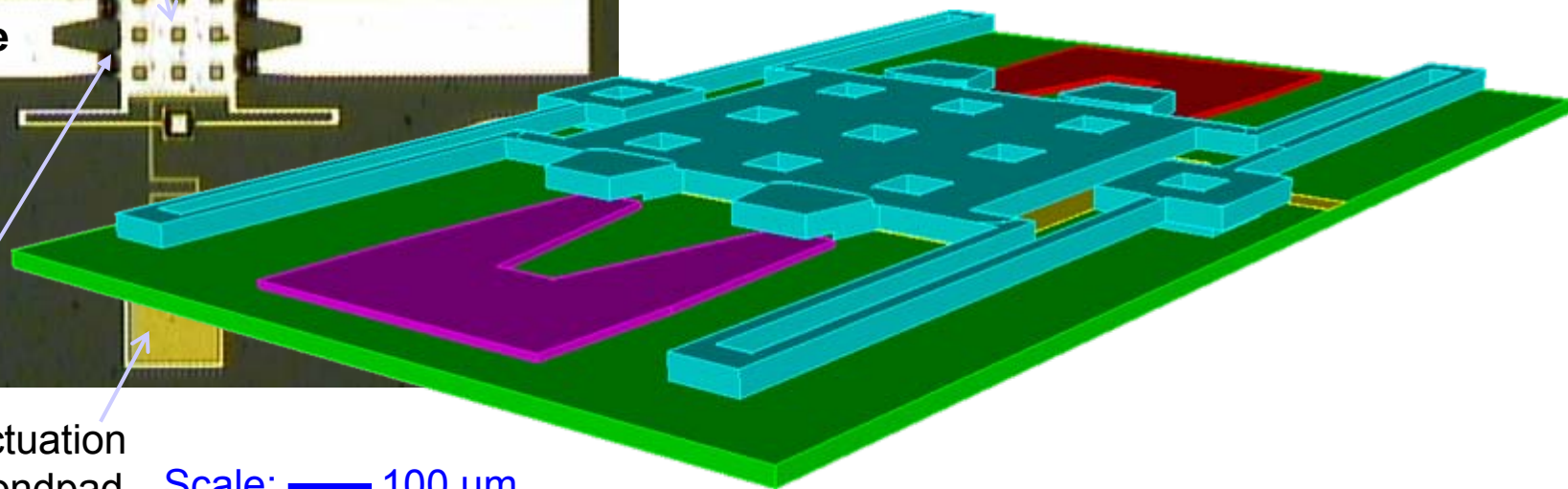Switch Plate
Ground Bondpad
Resistor
Signal Line
Contact
Actuation Bondpad

Scale: —— 100 μm
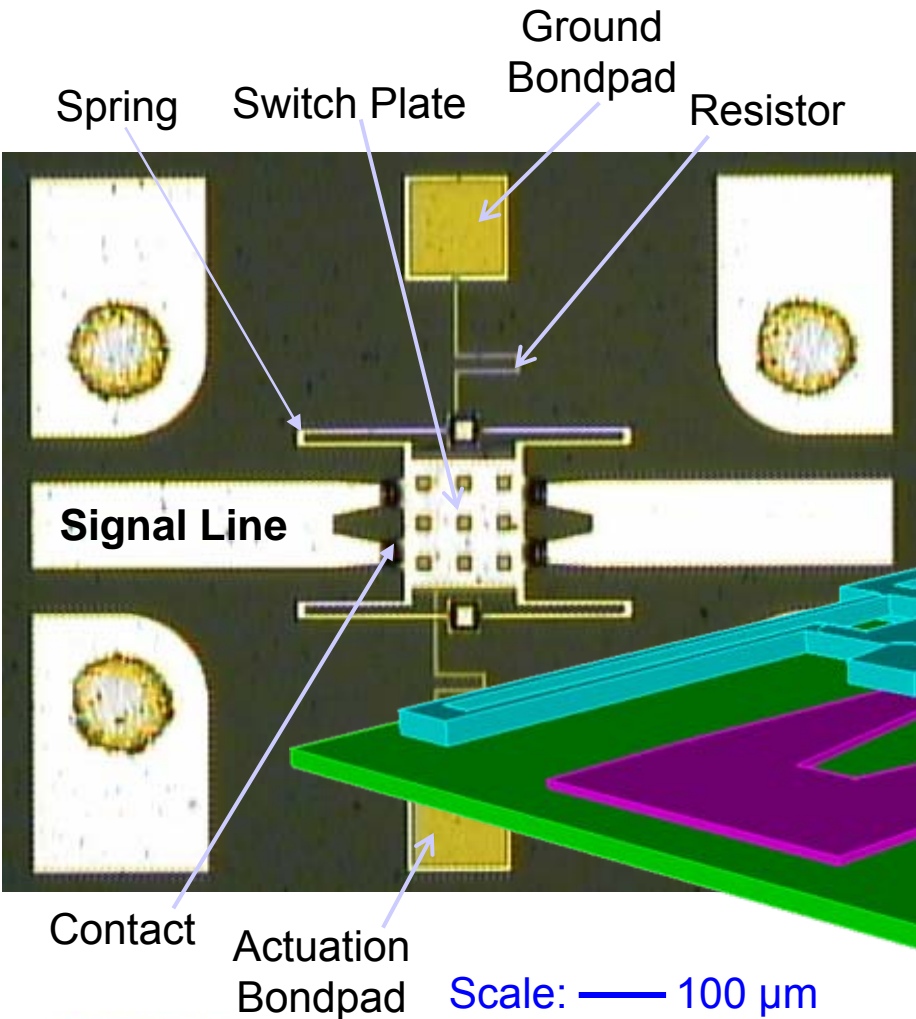
- Driven by control voltage via parallel plate capacitance.
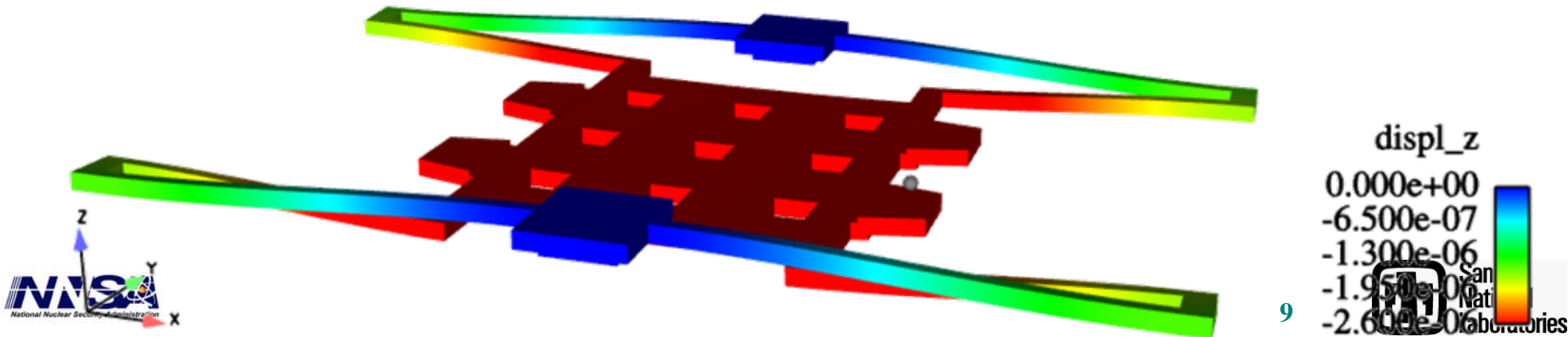- Gold structural suspension.
- Desired closure in 20 μs.

*Chris Dyck, January 2005.*

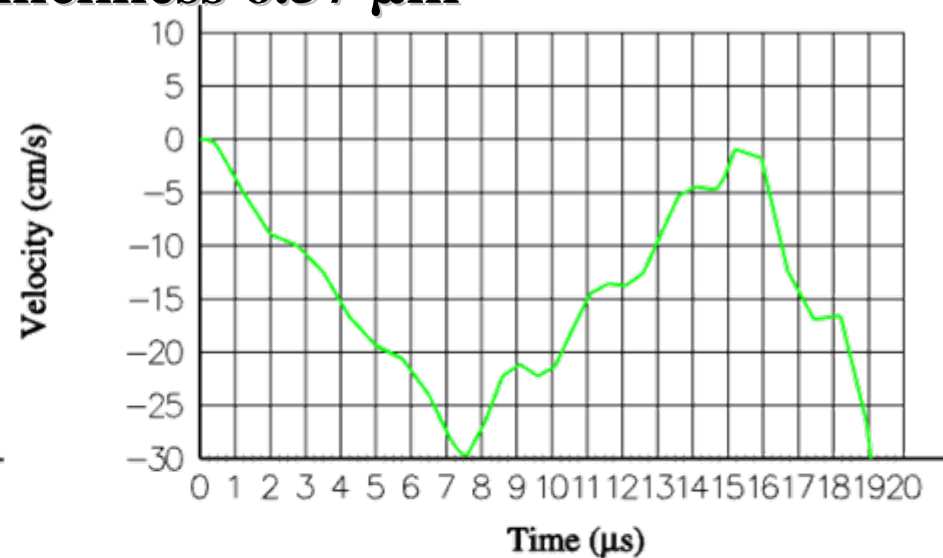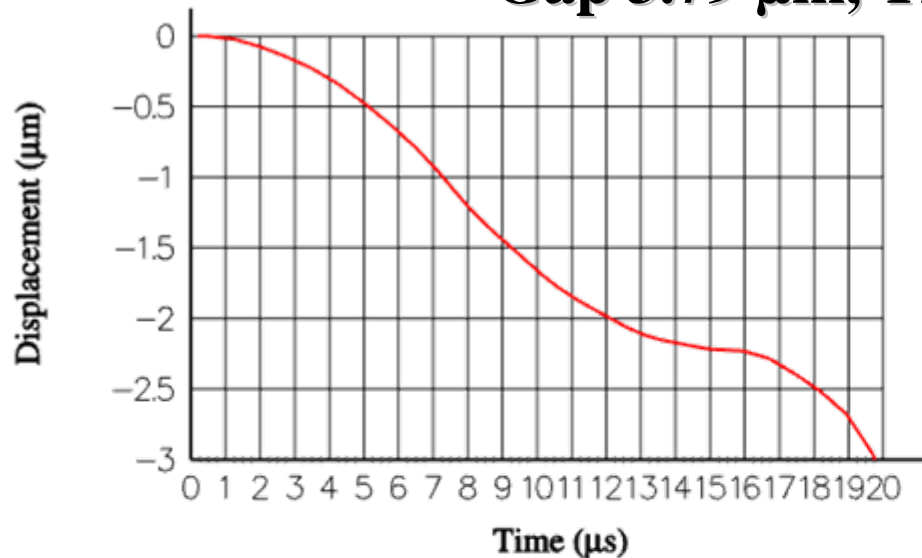# Background for Sim. Animation

- 156.8 V for 7.1 µs, 100 V Hold at 15.2 µs (0.5 µs slew time).

**Gap 3.79 µm, Thickness 6.57 µm**

# Design Optimization Approach



Spring  Switch Plate  Ground Bondpad  Resistor

Signal Line

Contact  Actuation Bondpad  Scale: ⎯⎯ 100 µm

- ***Change the 3D Retractor Topology***: Replace springs with electrostatic rocker - cantilevers
- Add 'UP' attractor plates under cantilevers
- Resonance energy reduced, raised a decade in frequency
- ***Shape optimization*** for dimensions, locations of cantilevers, ES pads

*Chris Dyck, January 2005.*
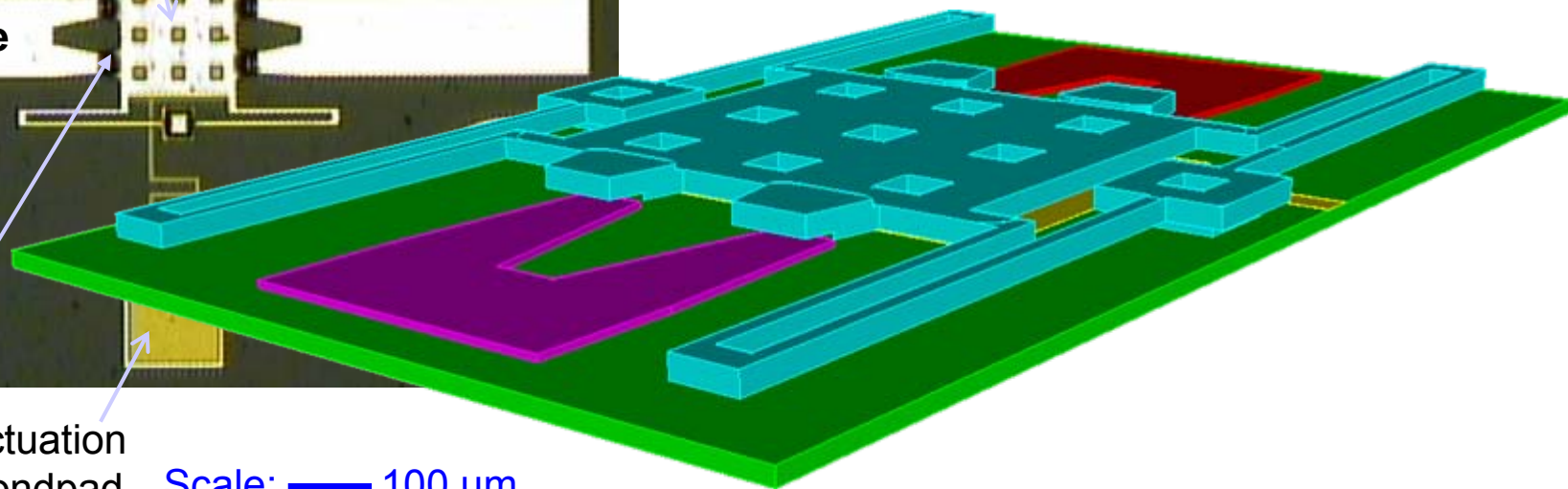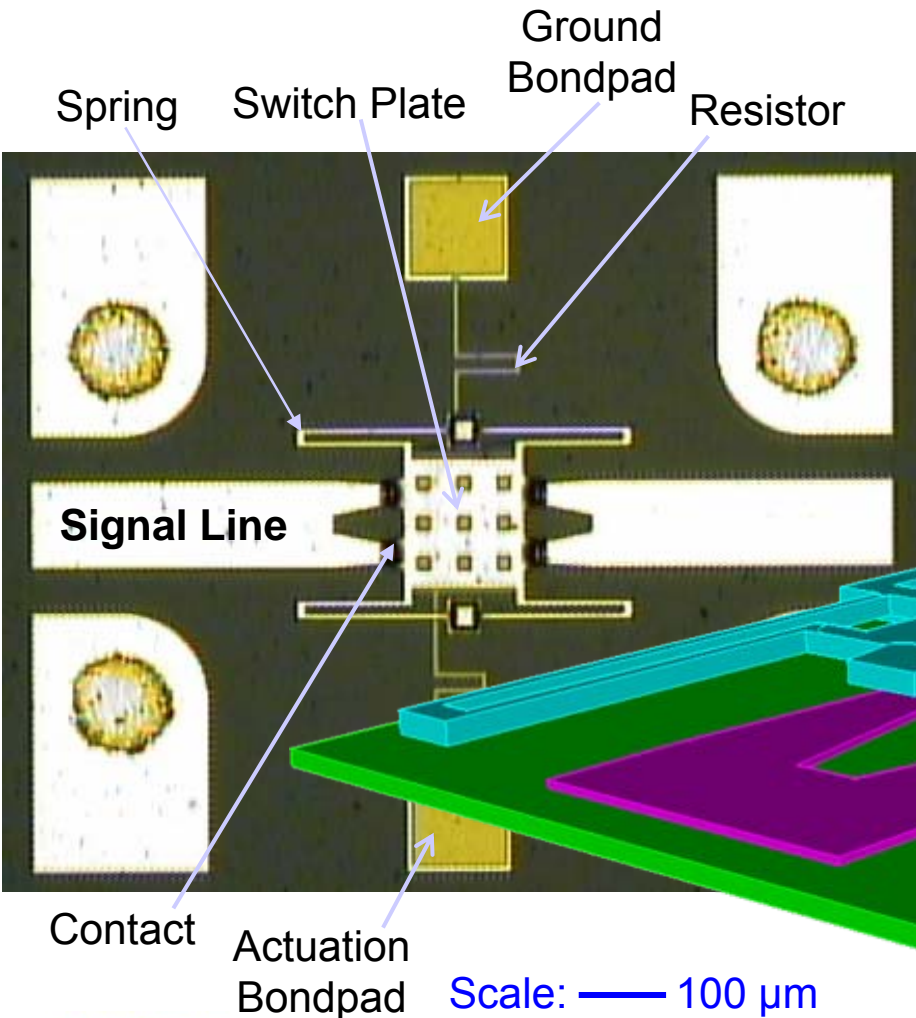
# Opportunities for 9200

**Mod./ Sim./Optimization in the hands of the Designer-Inventor**
>Role of M/S/O for new design different than qualification/certification

**Multiphysics/RF Simulation**
>RF Codes Emphasis and Eiger are standalone
>Dynamics
>Eiger-Xyce?

**Reliability-Robust Design**
Now doing design under (Fab) uncertainty w/o tools

**Characterize Fabrication Uncertainties**
 Fabrication variations are large, treated empirically by 100% test
What are the drivers?

**Connect experiment and simulation results – Predictive Science**
 Lots of arrayed experimental data

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